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(3) *They should be hung on a frame,* and a square frame is better than a round one, over the bed. Not too high to prevent one from killing any mosquitoes which have gained entrance. By lashing sticks vertically to the four corners of the bed and joining their tops with cord a frame of cord can be made.

(4) *They should not go outside the bedstead.* Neither the headboard nor the foot should be included, but they should come inside of both so as to be tucked under the mattress all around and they should be full enough and long enough to enable one to do this easily.

(5) *They should be thus tucked under the mattress* when one goes to bed and not allowed to trail on the floor. This will allow any mosquitoes which may be under the bed to get at the sleeper. The wind too may blow the loose bar aside and lift it from the floor.

Even when the bar is perfect and perfectly arranged it does not protect when any part of the sleeper's body comes against it—as the mosquitoes can bite through the bar even if they can not come through it. This was especially noticeable with the narrow cots and hospital beds in the Canal Zone. Of course it furnishes no protection until one has gone to bed—although this being the time of greatest risk of malarial infection is the time when protection is most needed.

Good bars well arranged and carefully used furnish much protection and on account of their cheapness should be universally used in malarial countries. They, however, give far less protection than screens. *Under ordinary conditions of malaria as we have them in the United States careful people in a properly screened house are safe.*

ENDEMIC GOITER.

ITS POSSIBLE RELATIONSHIP TO WATER SUPPLY.

By Taliaferro Clark and Claude C. Pierce, Surgeons, United States Public Health Service.

The use of certain kinds of water for drinking purposes, especially hard water, has long been considered instrumental in the causation of simple thyroid enlargement. In the Milroy Lectures on the Etiology of Endemic Goiter, delivered before the Royal College of Physicians of London, January, 1913, Maj. Robert McCarrison,[1] of the Indian Medical Service, reviewed exhaustively the literature of the affection and set forth his own conclusions relative thereto, based on actual experimentation.

Endemic goiter is present in many parts of the United States, especially in the region of the Great Lakes and in certain sections of West Virginia. A review, therefore, of McCarrison's lectures in connection with epidemiological observations made in the course of a survey of sections of West Virginia is considered of timely interest.

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[1] The Lancet, January 18 and 25, and February 8, 1913.

Geographical Distribution.

Goiter is very generally distributed throughout the entire world, but the incidence of endemicity varies greatly. In certain parts of England the affection is so common as to have acquired specific names according to locality, such as "Derbyshire neck."

Baillarger estimated that in 1874 there were 500,000 cases of goiter in France alone.

In Switzerland 12,207 men were exempted from military duty on account of goiter during the period 1875 to 1881.

In Italy, from 1859 to 1864, 3 per cent of conscripts were excused from service on account of this affection.

McCarrison's observations were made in the heavily infected Gilgit region of the Indian Himalaya Mountains. In a population of 70,000, 2 per cent were recently found to have goiter, and of these, 200, or 14 per cent, were cretins. The percentage of cretins among the goitrous of European countries is even higher, according to McCarrison. The association of cretinism in high proportion among the goitrous people may have an important public health significance to this country in connection with immigration from endemic centers. This condition does not obtain in the United States. In our experience cretinism is a comparatively rare affection in heavily goitrous communities.

Clark examined 13,836 school children in 11 counties of West Virginia during the fall of 1913 and found 1,234 cases of goiter, or 8.91 per cent. He also examined 6,432 public school children in 9 Virginia counties and found 817 cases (12.7 per cent) of simple thyroid enlargement.

Goiter among West Virginia school children.

County.	Number examined.	Cases of goiter.	Per cent.	Remarks.
Boone	297	7	2.75	
Cabell	2,947	504	17.10	Huntington.
Fayette	1,463	67	4.57	
Kanawha	2,662	139	5.22	
Logan	1,046	38	3.63	
McDowell	703	92	13.08	
Mercer	2,153	258	11.98	
Mingo	781	22	2.81	
Raleigh	311	6	1.92	
Wayne	1,001	99	9.89	
Wyoming	472	2	0.42	
Total	13,836	1,234	8.91	

Goiter among Virginia school children.

County.	Number examined.	Cases of goiter.	Percentage.
Buchanan	261	19	7.27
Carroll	249	57	22.89
Dickenson	358	31	8.65
Grayson	1,060	121	11.41
Lee	842	115	13.65
Scott	504	44	8.73
Smyth	392	65	16.58
Washington	1,097	126	11.48
Wise	1,669	239	13.72
Total	6,432	817	12.68

Not one case of cretinism was seen among these.

In a study of the geographical distribution of endemic goiter, according to McCarrison, these two facts stand out:

1. Its marked association with mountainous regions.
2. The practical limitation of goiter to temperate and subtropical regions.

It is true that goiter is found among people living in flat countires and that some mountainous regions of Norway and Scotland seem practically free from the disease; still, the vast number of cases are found in mountainous districts, especially of the subtropical and temperate zones.

Influence of Race.

All races are subject to goiter. One of us has observed a high percentage of goiter among the Indian population of Minnesota, Wisconsin, and Michigan.

In the colored high school at Charleston, W. Va., every girl of the senior class suffered from thyroid enlargement.

It is doubtful if heredity or family predisposition plays an important rôle in endemic goiter. It is more probable that certain families, remaining in one location, are subject to the same injurious influences and develop goiter in greater proportion.

According to a physician of West Virginia, goiter could be traced through several generations of his family and its collateral branches.

It is certainly true that the degree of endemicity varies in different localities, as is markedly shown in the preceding tables.

Goiter has appeared in districts previously free from the disease, and has disappeared from infected areas. These changes have been attributed to change in the water supply.

Seasonal Prevalence.

In India, the new cases appear and recrudescences take place during the spring and autumn, periods of moderate heat, corresponding to the rainy season or its close. McCarrison infers from this that the water supply at this period is contaminated by surface drainage from cultivated fields.

Dr. H. A. Barbee, of Point Pleasant, Mason County, W. Va., in a personal communication, related the occurrence in his practice of 16 cases of acute thyroid enlargement in young girls from 14 to 19 years of age, during the period of low water, in the summer of 1913. The water supply of Point Pleasant is from the Ohio River, obtained by wells driven in the river sand at the low-water mark. All of these cases developed within two weeks, were placed on bottled water or boiled water, and within six weeks all had recovered, with the exception of two.

Influence of Age and Sex.

The most startling feature of epidemics of goiter is their occurrence in endemic centers. Young people are most susceptible. According to McCarrison, susceptible individuals develop thyroid enlargement within six weeks to three months after arrival in a goitrous locality. These incipient goiters almost invariably disappear when the patient leaves the locality where the infection (if such it be) was contracted. He says, moreover, that removal for a short distance will effect a cure, provided the change gives the subject water from another source. We do not consider that change of environment necessarily proves the elimination of the causative agent of goiter, because of the known fact that simple goiter, even in endemic centers, undergoes exacerbations and remissions to the point of complete recovery, without noticeable glandular enlargement. In other words, the gland seems to gain its equilibrium and to adapt itself to an injurious environment.

He also states that in his experience the affected thyroid increases in size with the advent of each spring and autumn, and after the lapse of a few years becomes greatly enlarged. The process is comparable to enlargement of the spleen from repeated malarial attacks.

Goiter is rare in very young children. McCarrison says there is no great disproportion between the sexes up to 20 years of age, but that beyond this period more females are affected than males. Almost one-third of the cases of simple goiter are found in people under 20 years of age. It is evident from our own observations in the medical inspection of arriving aliens, and the record of rejections for enlistment in the military of European countries, that thyroid enlargement in the male is vastly more common in these countries than with us of the United States.

Clark examined 415 pupils of the high school at Huntington, W. Va., and found 128 cases of simple thyroid enlargement, all of them young girls. About 50 per cent of the girl students of this school were affected. Less than one-tenth of 1 per cent of goiter found in his survey of the Virginias was among school boys.

Occurrence in Animals.

Animals also have goiter, especially mules, horses, and dogs. This is apparently not true of all endemic centers. McCarrison examined all the dogs of a very goitrous village and found none of them affected. However, in the region of the Great Lakes, goiter is reported to be very common among dogs. It seems as if animals have greater powers of resistance to harmful influences in this respect than man. This fact must be borne in mind in attempted experimental production of goiter in the lower animals.

Rats are also susceptible to influences producing goiter. Marine and Lenhart also observed goiter among brook trout in fish hatcheries in Pennsylvania.

Influence of Water.

Dr. Graf, speaking on the subject of goiter in Vienna, January, 1912, said that in some places recruits were in the habit of drinking water from certain springs, with the result, that after about four weeks of the practice, they showed a marked enlargement of the thyroid gland which caused their rejection by the recruiting authorities of the army. After exemption from military service they would boil water, from the same source of supply, before drinking and effect a cure within a short time.

Further presumptive evidence that goiter is a water-borne disease is furnished by a locality with two sources of water supply, where those using water from one source become affected and those restricted to the other supply remain free from goiter.

This condition exists in certain villages in the Gilgit district in India. Here eight villages, adjacent to each other, derive their water from a neighboring stream and all are badly affected with goiter. Another village in the same district takes its water from a spring and has no goiter.

The drinking of rain or cistern water, or boiled water, in this district is said to prevent goiter. The effect of change of water supply on the incidence of goiter has been recorded in some cases. For instance, in Vienna in 1885, it was noticed that goiter had greatly increased during the previous decade, which was attributed by investigators to the introduction of a water supply from Styria, where goiter is endemic.

Another case where change in water supply is said to have influenced the prevalence of goiter is that of the village of Bozel, in Tarentaise. In this village, during 1848, out of a population of 1,472, there were 900 cases of goiter and 109 cretins. About this time a new water supply was introduced from a source only 800 meters distant, and 16 years afterwards, among practically the same population, there were only 39 cases of goiter and 58 cretins. Similar improvement has been noted in other localities following the introduction of a new water supply.

The Influence of Geological Formation.

The chemical constituents and bacterial content of drinking water in any locality are largely influenced by the nature of the soil and the underlying rock strata. Goiter is most prevalent in the regions underlaid by the Silurian, Carboniferous, and Permian systems; while those over the eruptive or crystalline rocks of the Archean group, the sediment of Jurassic, Cretaceous, and post-Tertiary seas, as well as all fresh-water deposits, are comparatively free from the affection.

In some cases goiter does appear in localities over the second group, but in these places the underlying strata are thin and ground water penetrates to lower groups. It is observed also that the influence of the first group is weakened or lost by superimpositions of the fresh-water strata.

Baillarger, in a masterly review of this subject in 1873, concluded that "it had not been shown that goiter prevailed exclusively on any particular soil, but that it seemed to prove that the endemic is extremely common on the dolomite formations and rare on others."

These observations are largely in accord with the geological formation observed, in goitrous districts of the two Virginias, by one of us.

An exception to this general rule is noted in the Northern Peninsula of Michigan, where Clark observed a considerable amount of thyroid enlargement among, but not exclusively confined to, the Indian population. Here the rocks belong to the upper levels of the Algonquin formation of the Huronian period.

On the other hand, over two-thirds of the area of West Virginia is underlaid by the Carboniferous system of rocks, shading off into the Devonian in the southeastern portion and the Silurian limestone of a large part of the section of southwestern Virginia wherein goiter is extremely prevalent.

It is of great interest to note, referring to the tables, that the counties of Virginia and West Virginia underlaid by Carboniferous strata have the lowest percentages of goiter, notably Boone, Fayette, Logan, Mingo, Wayne, and Wyoming, while Cabell County, represented by the city of Huntington, in this survey is on the outer edge of this coal-bearing stratum and has the highest percentage of goiter found in the State.

The same holds true of the Virginia counties investigated. Buchanan and Dickinson counties belong to the carboniferous system and have a lower percentage of goitrous school children than were found in the limestone section represented by Carroll, Grayson, Smyth, and Washington counties.

A very noticeable endemicity of goiter is found along the course of the New River. Rising near the Virginia-North Carolina line, it flows northeast through Grayson and Carroll counties, which have a great amount of simple goiter. It continues into West Virginia in a northwesterly direction, near the Mercer County line, in which county the next highest percentage of goiter was found in that State, to empty, finally, into the Kanawha, near Montgomery. The percentage of goiter found in Fayette County was only 4.57 compared with that of Montgomery, 7.04.

Relationship of Chemical Substances Found in Water.

A chemical analysis of water in goitrous regions has failed to show any relationship between the dissolved salts and goiter. Goiter has been found endemic in regions of both hard and soft water. The use of hard water seems to favor the development of goiter, but not to cause it. It is inferred, because the thyroid gland regulates the metabolism of calcium and magnesium salts introduced into the body, that when a diseased gland attempts this work hypertrophy takes place.

Rêpin believes that goitrous waters are radioactive mineral waters of high carbon dioxide content, which hold an excess of calcium and magnesium salts in solution.

Recorded chemical analyses of water of goitrous districts have not shown, to our satisfaction, that goiter may not be a deficiency disease, and that the water of such districts may not be lacking in some ingredient necessary to the animal economy. For instance, the normal thyroid contains a small amount of iodine in combination with protein or albuminous material. This iodine content is greatest in the normal gland, less in the colloid variety, and least in that of the parenchymatous hypertrophic form. The opinion has been advanced therefore that waters of goitrous regions may lack certain chemical constituents, notably iodine.

Efforts have been directed in the past, in so far as the chemical substances in goitrous waters are concerned, to determine what such waters contain, rather than what ingredients necessary to the animal economy may be lacking.

Nature of the Toxic Agent.

McCarrison believes, from a study of the behavior of endemics and of authenticated outbreaks occurring in his own experience, upon conclusions drawn from the work of Marine and Lenhart upon the disease as it occurs in artificially bred trout, and, finally, upon his own experiments upon man, and more recently Bircher's on rats, that endemic goiter is due to the existence of a specific living excitant.

The Swiss Goiter Commission found that goitrous waters gave a higher bacterial count than nongoitrous waters; and McCarrison has noted the same thing in a certain stream of India. Plate cultures were made, and it was found the farther down the stream, on the banks of which were located numerous villages, the samples were taken, the higher the bacterial count, which coincided with a greater incidence of goiter.

According to McCarrison this seems to show a direct relationship between the affection and the degree of bacterial contamination of the water supply.

Howell reports that in the district where he investigated endemic goiter, in New South Wales, only rainwater was used. In this district, about 20 miles wide by 30 miles long, there are no streams, and the water is collected from roofs into cisterns. These tanks are not frequently cleaned. He examined 100 of these, and all of them gave a very high bacterial count.

McCarrison claims that the presence of endemic goiter in this region can be explained only by the contamination of these tanks by living organisms, and not in any way by dissolved salts.

This view seems to be substantiated in a series of observations by Marine and Lenhart at a fish hatchery located in the mountains of Pennsylvania. The fish houses were placed in series, and the water from the upper flowed through those located farther down the stream. The fish became affected with goiter. On examination it was found that the incidence of goiter varied from no cases among the trout taken from the stream above these houses, to 84 per cent in the house farthest down the stream. It was furthermore observed that the goitrous fish removed from these tanks recovered when placed in clean, fresh water.

Moreover, when nonaffected fish were introduced into the tanks from which goitrous trout had been removed, they also developed goiter. McCarrison thinks this indicates the presence of an exciting agent left behind in the tanks from which the goitrous fish had been removed.

Experimental Production of Goiter in Man.

McCarrison conducted a series of experiments to determine the possibility of artificially producing goiter in man, under the following conditions:

> The men were volunteers, between ages of 18 and 25; they were newcomers to the district; they were under observation for some time prior to the commencement of the experiment; they lived in a nongoitrous part of Gilgit, under the strictest guard; they were encamped on ground which had never been cultivated; they did no work and were not permitted to handle the soil; they were provided with water for all domestic purposes, brought from a spring in a nongoitrous district, at the point of its exit from the hillside, which, as an added precaution, was boiled.

Water was taken from goitrous streams, after the water had been made muddy by agitation, passed through a Berkfeld filter, and the retained sediment washed off with distilled water. Four ounces of this mixture were given in milk each morning, before the first meal, to each subject.

Of the 36 persons submitted to these experiments, 10 developed notable thyroid enlargement, 5 showed transitory thyroid swelling, and 20 suffered no change. On the other hand, not 1 of the 31 persons who drank the same material after boiling developed goiter. The conclusions drawn by Mr. McCarrison from these experiments were:

1. Thyroid enlargement can be produced in a few weeks by suspended matter separated by filtration from goiter-producing water.
2. Thyroid enlargement can not be so produced when the sediment is boiled.
3. Goiter so produced can not be due to mineral matter, but is due to a living organism.
4. While it can not be positively stated that a Berkfeld filter removes the cause of goiter, water so filtered can not produce goiter within 56 days (the period of McCarrison's experiments).

Bircher, in 1909, arrived at certain conclusions as a result of his experiments in producting goiter in rats, as follows:

1. Thyroid enlargement does not arise until several months' subjection to the toxic substances contained in the water.
2. Goiter can be produced in rats by natural water from goitrous springs.
3. The toxic substances are destroyed by heat (boiling).
4. They are not removed by a Berkfeld filter. (Contrary to McCarrison's observation.)
5. Centrifugalization renders the pathogenic water innocuous.
6. The addition of certain chemicals, as hydrogen dioxide, renders the water harmless. (Marine and Lenhart have shown that the addition of iodine in the form of a small amount of Lugol's solution causes rapid disappearance of thyroid hyperplasia of trout.)
7. Dialysis removes the goiter-producing substance from the water.
8. Substances separated by the membrane of the dialyser can produce the disease.

McCarrison has collected presumptive evidence that soils become infected with the exciting agent of goiter, and that water flowing over or through these soils take up the organism.

Pollution of the soil in itself may not necessarily furnish an infective agent, but may provide the necessary environment for the inciting organism to develop by supplying the proper pabulum for its support. This may explain why the same water may or may not produce goiter.

The ideal conditions for a goitrous region are, according to McCarrison, "a country district, inhabited by agricultural people, living on porous soil, in the presence of abundant organic material." By virtue of the porosity of the soil or the slope of the country, the organic matter is carried by rains to the streams and wells that furnish the water supply of the inhabitants.

It is in limestone regions and mountainous districts that such conditions are usually found; consequently goiter is preeminently a disease of hills, and its relationship to such topography is clear.

In 1909 McCarrison examined the feces of 103 persons suffering with goiter, and in 87 cases found an ameba, which he was not able to classify; in 48 cases it was found in large numbers; in 27, in moderate numbers; and in 12, only in small numbers.

The feces of 101 nongoitrous persons living in the same locality were examined at the same time, and only 29 persons were found to harbor the same ameba; of these 29 cases, 8 had it in plentiful amount, 9 in moderate amount, and 12 in small numbers.

McCarrison also claims to have found a spore-bearing organism in the feces of goitrous persons, that resisted boiling for several minutes. Vaccines made from cultures of this organism seemed to have curative properties.

Summary.

After a careful consideration of McCarrison's lectures on the etiology of endemic goiter, our conclusions are as follows:

1. The cause of endemic goiter is not yet determined.
2. The extensive prevalence of goiter in rural communities, where families are widely separated and have separate water supplies, tends to preclude the possibility of the affection being due to a water-borne, living, organic excitant.
3. The enormously greater prevalence of goitrous endemicity in regions underlaid by carboniferous, devonian, and silurian strata can certainly bear some relation to the water supplies, which should carry in solution (or do not, as the case may be), the same or similar chemical substances.
4. The observations of Howell on the prevalence of endemic goiter, in an arid region of New South Wales, in which the sole water supply is impounded rain water gathered in cisterns, point to the probability of the affection being due to a deficiency of certain necessary chemical substances.
5. The experiments of Marine and Lenhart, by which goitrous fish were cured by the addition of iodine in the form of Lugol's solution to their water supply, indicate that the affection may be due to a lack of iodine in the drinking water, or in vegetables grown on the soil of goitrous districts. In fact the administration of iodine, either locally or internally, is a recognized method of treatment of the affection in man. Many recoveries are reported as due to this treatment.
6. The experimental production of goiter in man by McCarrison is in need of corroboration. His interpretations are also somewhat indefinite.